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An Inaugural Essay

On the

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very good -

Circulation of the Blood.

Submitted to the Medical Faculty, *Provinc.* &c.

of the University of Pennsylvania,

For the Degree of Doctor of Medicine.

by

John Josiah White.

of

Philadelphia.

At the beginning of the

Revolution of 1776

the people of the United States

of the United States

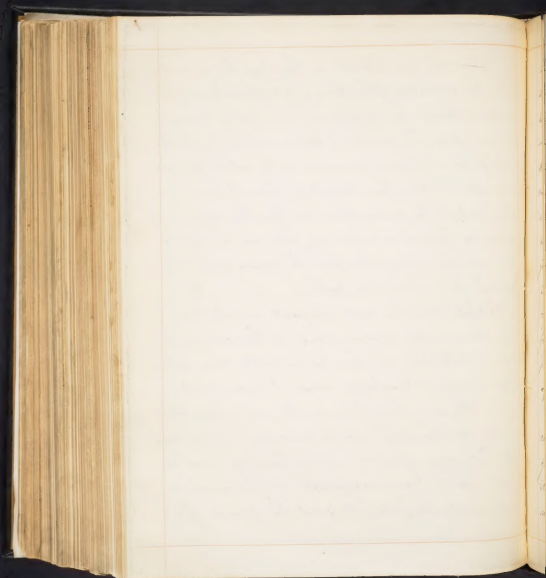
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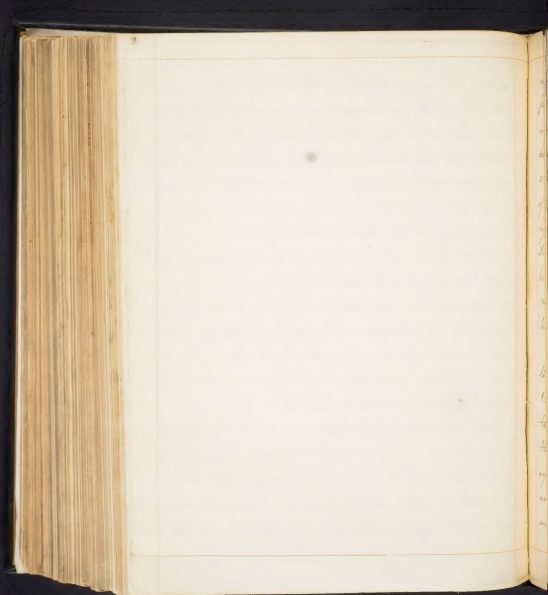
There are few subjects in Physiology, less understood than the circulation of the blood; from the intricacy of its movement through the capillary and venous systems, it seems to have eluded the researches of science, and most of the theories formed on it, and disseminated in the schools, are based more upon conjecture than observation: hence it becomes a proper subject for examination, how far these different views are founded on reason and fact, and to what extent we may select matter from the various conflicting opinions to arrive at the truth.

Richard being the most prominent amongst those who have enriched Medical Science in this, or any other age, I shall freely draw from his invaluable Stores, as the best repository of knowledge; indeed it is my intention to do little more than follow in the path, already beaten by this great luminary, and by cancelling whatever starts up, that may appear not clearly elucidated, I can at least hope to become acquainted with his principles and instructive facts; it is not the province of a



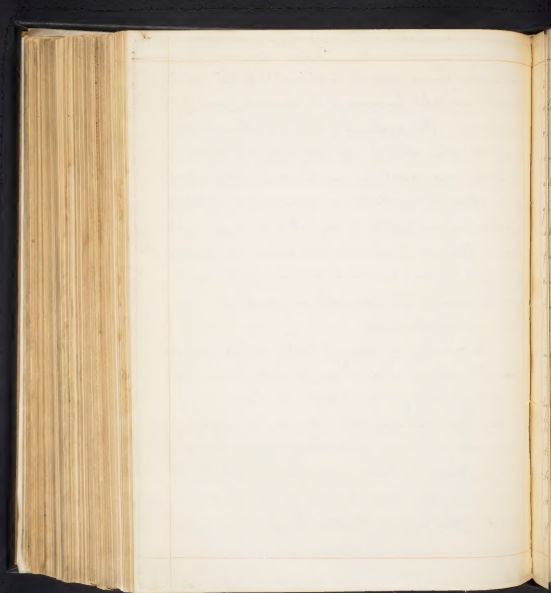
Student, to seize boldly on the helm of discovery, and steer through the quicksands of error, or avoid the dark delusions that attend even the most skillful: this belongs undoubtedly to the practised mind of the physician: it requires knowledge, ample experience, and the wisest tact: the perseverance of a Morgagni, or the genius of a Fracastoro. But, by examining, with due deference their theories, to acquire a habit of thinking boldly, of concluding correctly, and deciding justly, is certainly within the limits of his capacity, and his imperative duty. — Impressed with these views, I have rejected the dubious chance, of experimenting with an unskillful eye, and deficient apparatus, for the less brilliant prospect, of following an author through his own discoveries, and offering my feeble comments upon them.

The circulation of the blood, since the time of its discovery, Harvey, has engaged the close study of every physiologist: and with so much labour already bestowed upon it, with so little success, may be supposed to possess no little intricacy. Notwithstanding the stream of talent



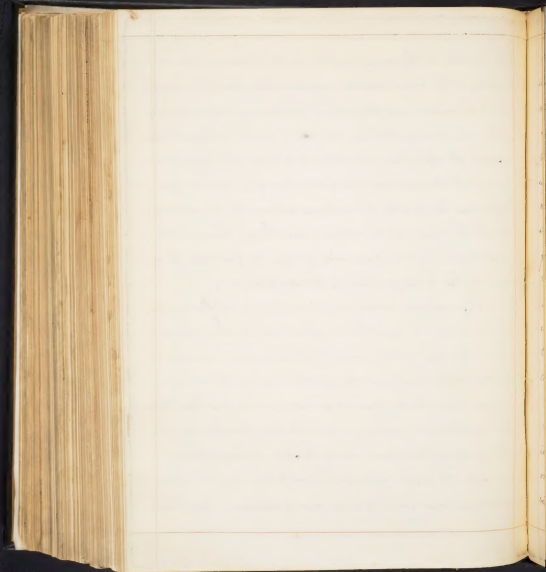
which have flowed upon it in modern times, the most important and vital phenomena of its movement, remain yet undiscovered. The mysterious return of its columns to the heart, the offices which it apparently performs of, nutrition, exhalation, and absorption, and the deeply hidden objects of the abdominal circulation, are explained only on conjectural hypotheses and contradictory theories. It is necessary for a philosopher or physician to cultivate these knotty subjects, and perhaps effect a great and final revolution in our sciences: until then we must be content to speculate, with our yet imperfect and broken chain of explanations.

The circulation is divided by Boerhaave into two kinds: viz. that of the red and black blood, the limits of each, being the pulmonary and general capillaries: the first or that of the red blood, commences in the extreme vessels, ramifying on the air cells of the lungs, which collecting into branches, and these again into trunks, it is discharged by four veins into the left auricle of the heart: thence it passes into the left ventricle and is distributed by its contraction through the aorta and



its branches, to the general capillaries: the route in this circulation of the blood, resembles radii proceeding from the superficies to the centre, and thence to an opposite and similar surface, or in other words, it forms two cones, joined together at their apices: at this place of junction, is situated the efficient organ of all its movements, the heart; this, being possessed of an apparatus for propelling the continued column, by its contraction forces the blood into the arteries, and through them, to the capillaries: it is supposed also, by many to facilitate the return of the pulmonary blood by its dilations.

This movement, however, simple as it may at first appear, is the subject of many theories, opposite in character, and of high pretensions. Harvey, and the mechanicians, referred it altogether to the heart, and consequently considered the arteries as passive tubes: Hunter, and most modern writers give these latter the attribute of muscularity, and make them serve materially in the motion of the blood, whilst Boerhaave, depriving them of muscular structure, considers their contraction only the effect of texture, and gives them a middle station. Albrecht





middle, which he considers, elastic and muscular, to
 the muscular being within it. The fibres of the
 muscular coat, he supposed to operate in the distention or con-
 traction of an artery to determine how far the distention was
 suited with its muscular coat & substance: but a fault
 he felt, and found the distention increased between the
 principal arteries, but did not return to their original dimen-
 sions: hence he was led to conclude that the muscular coat
 when stretched after death is not return to its original
 dimensions: a muscle once stretched after death is not
 elastic at all; but according to his results the artery was
 reduced to nearly its original diameter: a human artery
 today today holding it in a state of extension, and was
 arrived at the conclusion that the contraction was less

the normal tension of the middle coat and the contractile
 power elasticity to the extreme or muscular. In the course
 of the artery the aorta, the elastic is more than
 the muscular, laminae. The middle coat of the
 middle vein, of the arteries, describes it as a peculiar form



from a certain point of view, it is a certain extent, but beyond that, an
 object is not a subject in relation to the others, and then
 becomes a subject, not simply, but necessarily, a subject. There
 is a certain point of view, more to be seen, a different relation
 in a certain case, I am inclined to say, but that the
 common foundation is a subject, it is some measure, some
 relation, which may be said to be a foundation to prove. The
 argument is, I think, certainly clear, what must be the
 fact that the object is not subject's relation, but the other
 way, also, that the subject's relation is subject to a new
 human relationship that is "none could discover the de-
 velopment of the human as subject." According to Dr. Buckle
 all the explanation is in the fact that a new ground was
 made possible to subject's relation in that human's development
 in subject's relation, more and more, and it is in the human's
 mind, and the new mind, but the new human must
 enter, it is the new mind, it is the new mind. The human



it not is such, as it is shown by the following proposition
 from Biot: "If we draw in a certain direction, the
 two ends of an elastic cord or muscle, one effort will move
 sufficiently in vacuum. In the first, when the cord body, is the
 subject of the combative experiment: and when the cord
 is elastic as elastic. The vessel of the is a very strong elastic
 mass, when it is, it would be to show that this action
 should be comparatively greater to move the muscle." The
 first experiment of Biot, was made a circular section
 of the cord, 10 inches, measuring 2 1/2 inches, as stretched
 to 10 1/2 inches. The force being sufficient to move it.
 Biot's remarkable vigorous dimensions. Why say at this
 'moving to an important, better number such as Biot
 described it' in the last small extent of thought to
 have been at 8 inches, instead, certainly, to achieve the
 two, which according to that, the Biot of muscular
 must be sufficient to break a mass when a 1/2 inch,
 should exhibit a vast difference in the two states, but then
 the same motion the muscle seems to be, nearly in equal







The second, or posterior coat, is called the membrane, often both different in its properties from the other, thinner, the latter is thicker, since in the interior of the heart, border to the coronary artery, the surface of that artery against the wall, shows, and enervement, and a small of contraction only to the first of these coats, the first or internal coat is thin and furnishes a smooth and lubricated surface for the motion of the blood. According to Vieussens, this is the seat of contraction, but the majority of anatomists consider this affection as located in the middle coat. Undoubtedly they comprise a set of equidistant striations, regular in distance, and in a certain point beyond which the two internal coats must rupture.

Thence we arrive at our conclusion, that the heart by its contraction, throws the blood into the aorta, which is generated by the semilunar valves. Now the mechanism of this operation, according to Vieussens is this: considering the aorta as a ligament almost inelastic, it must follow, that when, by its force the arteries have been dilated to their maximum, the remainder must enter the capillaries with the same velocity.



arteries united, not that, which flows in the aorta; the sum of the areas of the extreme branches however, is greater than that of the aorta; hence the blood will circulate there, in less time in the aorta, and this coincides with the 1st. circumstance of Spallanzani.— I consider the blood as an almost inelastic fluid, and what little it requires to compress it, for its compression, is scarcely worth naming; the vessel it is in, when the blood does not cease to flow in an other stream, is because of the elasticity or contractility of the vessel, this being stretched to its maximum point, by the force exerted on the blood, it follows, that the remainder must be the same, that a liquid would in a vacuum a metal pipe, or in other words, that there is no difference of space between what is one part of the body it will, & what is the same in space.

From the known principle of hydrostatics, that a fluid will not pass beyond an angle in the same substance with the same velocity, which it first moved, it has been thought that the arteries might lose their ability to contract with



[illegible]



in a slight degree upon its contents, from the contractile nature of the first set of blood-vessels it is the point beyond which it cannot go, and then the force & velocity are simultaneously increased. — Considering the system as a whole we find that the velocity of the blood is not increased in the arteries, but this occurs only in the commencement of the systole, and before the tube is filled by having obtained its extreme degree of dilatation. Admitting these considerations to be correct we have no more of these dilatations beyond each curve in advance as the heart will just as well, say, better, without them. If the blood move, as I have stated, the want of dilatations can have no influence on its velocity, and inasmuch as the surface of the artery is extended, it will have a tendency to rupture, exactly on the principle of a hydrostatic bellows. If the artery be dilated to twice its natural size, without a proportionable increase of thickness, there will be at least 4 times the pressure, originally contained; thus, the three additional dilatations exist, and without an increase of particles the pressure must be increased with the size



now, and of course the same is to be expected in the
 interior vessels, you cannot determine its position by the
 thickness of the surrounding column, & the non-elastic part
 only, would submit it to the same laws: the tissue moves
 simultaneously in all its parts, when confined to a regular
 cylinder.

It is very true that the aorta possesses
 especially in old subjects, a considerable dilatation at its
 great curves; but, of the preparations I have examined, as
 far as I could see, this dilatation does not correspond to what
 it ought to exhibit, were its chief use that in the human
 being. In an angular tube, the increased circumference
 should be just beyond the bend, because the impediment
 exists at its extreme boundary, and until the bend has reached
 that impediment it rises but little of its magnitude. This
 however does not hold in the aorta, for the dilatation ex-
 ists immediately in its curve, and is lost even before that
 curve is completed. How then can this dilatation be
 related to the passage of the blood? that it does, is evident,
 as it would not exist. Look at the innominate, the



the left carotid, and subclavian arising from its upper portion
 is it not ^{or} deluged the entire transsection of the blood into
 these vessels? And is the use I would assign to it, and
 use the only object it can be calculated to fulfil.

If the position I have attempted to disprove be true, certain
 to this circulation, should exist in the carotid system, which enables
 us to see the great cause before it gets into the cranium
 yet I have seen a state of circulation, in which this state
 was rendered evident. I will however repeat the position
 I have attempted to prove from one source, & see, by a reference to
 the experiments of *Spallanzani*. In his 2^d exp^t, he found
 that in the human artery the section of the blood ^{was} "was the
 same, whether it be the angle, formed by these vessels."
 experiment 11th. "The blood circulated with its usual velocity in
 an intestinal vein, although it had 23 curvatures." These ex-
 periments furnish collateral evidence to show the non existence
 of obstructions, otherwise the blood could not have flowed with
 great velocity.

I therefore think the position, which Bichat is shown



newly mass. viz. that the heart has a simultaneous movement
 throughout the systole, and the pulse, not only its own, but
 Gallagaoni's experiments, and as a consequence, the expansion
 and the artery, have in effect, a diminution of the circulating
 mass. Also, that the elastic tissue of the arteries, contains
 no built own interest & vital or, it may be, mechanical
 properties, when such vessels of the heart, must necessarily
 be again restored to their maximum point of distention, before
 their action. The systole has distention taken place simulta-
 neously throughout, the maximum point of distention is
 that point where the arterial fibres of the middle term are
 brought to their stretch, or in other words, is a succession
 of events upon an elastic tube with limit its distention, so
 that circular fibres act upon the artery. Richard observes
 that "the circular fibres diminish as we approach the
 branches of the arterial tree", thereby proving their use in the
 structure to be contrary to the opinion of many writers.

He supports the pulsation in arteries. Richard & Hunt
 has settled the point, that the pulsation is the locomotion



a man suggest this allude to circulation and in the
 same is another strong argument, a favor. This position, also
 states, that the column at one end moves, as at the base,
 for if it did not, this compressive and dilatation effect to
 become there, it would not take place; the water would
 rise in circulation corresponding to the force, but not the
 motion of the root, and we should feel the pulsation in
 the vessels before the extreme arteries. This can be as well
 the case, every pulsation in the vein is sent with full at the
 same moment towards the system. Hence, the blood, driven
 into the capillaries and around the members by that to drive
 it into one before the pulse; but the direction of the artery,
 is everywhere the same, with the motion, it is elastic, firm &
 thick & transmits the pulsation & the pulsation to some extent
 back. Now the pulse, & the vein, the only 6 of this in
 the, we should observe that the pulsation is there.
 This Richard proved to Simon Leger, in action and a vein
 and when the hand is a loose, constant pressure in
 action, pulsing could be felt in the vein, but a hand at



nothing, whilst the artery pulsates as usual. The best illustration we can have of the arteries in situ, is afforded by a leaden pipe of a hydram, which may run uncovered in a tortuous direction. Here, if the stream be permitted to flow, & then suddenly stopped by means of the cock, which will answer to the flow given the column to the heart; we perceive a quick locomotive effect, corresponding exactly to the pulsation of the arteries. It is on this principle that the pulsation of the heart against the ribs can be accounted for, & on no other so satisfactory.

During the last winter I examined the arteries, & the blood vessel enters the capillary system; and at this stage we have the work of disordered opinions; the mechanicians held that the red vessels were not in the arteries; an opinion by no means the least plausible, formed; & has been revived in France, that the pulsations of the red blood vessels are not in the arteries, but in the veins. Whatever value we may attach to the arguments in its favour, it cannot explain the various phenomena



[illegible]



... it will be demonstrated. That these mechanical laws will solve the difficulties which encounter us here is certain. Every thing that we possess, will in rational principles, and with admitted facts, explain to us, why the blood which until birth has passed from the pulmonary artery, into the ductus arteriosus, at that period ceases to flow in its former channel: although in anatomy it is open, and the pectinate muscles seem sufficient to propel blood in to it? This, amounting more or less to a similar nature will demonstrate the utter futility of solving every problem, in which nature has interpositioned her laws.

It is the opinion of several, that the blood has an extraordinary movement given it in the capillaries; but such a motion appears very inadequate to the effect designed: When we consider the structure of the veins, and their valves, may we not attribute some of the capillary phenomena to a similar construction. I must confess, I am rather sceptical, on the extensive uses of the venous valves: that they have some other use, besides supporting the column of blood merely, I think may be safely concluded: and if then extends to the capillaries



along with the osseous fibres, I think some future day, will assign a more probable use than is generally attributed to them.

These latter, viz: the osseous fibres, run in a longitudinal direction. I have already endeavoured to show that the arteries exert their influence in resisting the great lateral pressure of the blood, which is beyond all comparison greater than the vertical, inasmuch as the lateral surface is of much more extent, than that of the ends of the arteries: reasoning from analogy, we should suppose that the osseous fibres resist the longitudinal stretching of the veins: this however cannot be since the force in that direction is very small: May they not then have some influence in the motion of the blood? It appears to me more probable, than the oscillatory movement of Riccati.

Dr. Jackson alleges, from microscopical observation, that the minute or extreme circulation is not performed in vessels: unless we consider the whole frame, as a series of connected vessels, we cannot, without this fact before us, believe in the omnipresence of the fluids: and with it the pathology of disease is intelligible and rational: yet it is certain that the



serous capillaries must have a commencement, which he thinks
 is in cut de sacs. This however, though doubtless correct,
 is but the connecting link: and without a cause of suc-
 tion to the serous blood, the chain of explanation is far from
 being complete: whether it be from capillary attraction, os-
 cillatory movement, muscular contraction, or some other power
 is yet to be determined. But the rapid march of Science,
 and the fresh discoveries, continually breaking in upon her
 clouds of Error and Ignorance, lead me to hope, that
 this with many other unsolved intricacies, will, ere long,
 be plucked from among the arcana of Nature, and added
 to the well earned treasures of Medicine. —

